Cold-hardiness of Vaccinium ashei and V. constablaei Germplasm and the Potential for Northern-Adapted Rabbiteye Cultivars

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Abstract

Cold hardiness evaluations were recently completed on a range of blueberry germplasm. Two notable determinations were the extreme cold-hardiness of V. constablaei Gray populations, and the exceptional cold-hardiness of ‘Little Giant’, a V. constablaei x V. ashei Reade hybrid. In recent years, the USDA has generated V. ashei - V. constablaei derivatives to provide late-flowering, early-ripening rabbiteye (V. ashei) germplasm for the southern U.S.; however, this germplasm has also performed well in New Jersey, and could potentially provide northern-adapted rabbiteye types. Rabbiteye has great vigor, heat adaptation, and excellent fruit quality (however, some cultivars may be seedy or gritty); it is early flowering, and late ripening. V. constablaei is very slow to flower, relatively early ripening, and also has good fruit quality. When combined, these germplasms complement each other in many respects. Particularly notable is the elimination of the objectionable grittiness in hybrid fruit. Hybrids are late flowering, mid- to late-ripening, and tend to be both dark- and small-fruited. It is expected that with further recombination and hybridization, it will be possible to select hybrids improved for critical commercial characteristics, and to derive selections suitable to locations ranging from the far northern U.S. to the far southern U.S.

INTRODUCTION

The observed cold-hardiness (or lack of) in southern-derived plant materials is a result of both mid-winter cold-hardiness and deacclimation rates. Southern U.S. blueberry growers like the growth habit of rabbiteye because it is vigorous, productive, and relatively carefree; however, rabbiteye cannot be grown in northern areas because of its limited winter hardiness, and rapid rate of deacclimation (loss of cold acclimation) once chilling requirements are satisfied. A solution to this may be V. ashei - V. constablaei hybrids.

V. constablaei is a highbush-like hexaploid species found at higher elevations in northern Georgia, western North Carolina, and eastern Tennessee. Its main characteristics are: extreme cold-hardiness, slow deacclimation, late flowering, and a short fruit development interval (relative to V. ashei). Its fruit are small, aromatic, and have very good quality. V. ashei is a hexaploid species grown commercially in southern areas with mild winters. Its main characteristics are: cold-sensitivity, rapid deacclimation, early flowering, and a long fruit development interval. V. ashei is vigorous, high yielding, and many varieties have a tendency toward “suckering”. Its fruit can be gritty, possessing stone cells, and its organic acid composition, with malic acid predominating, can result in a blander tasting fruit than that of northern highbush.

Hybrids with V. constablaei can yield more desirable rabbiteye types for the South because it makes rabbiteye hybrids flower later and ripen earlier. Successful crosses of this type have yielded earlier-ripening rabbiteye types, for example, the Florida cultivar...
'Snowflake'. Additionally, V. constablaei introgression has already yielded a rabbiteye-type derivative suited for the North. 'Little Giant', a processing hybrid grown in Michigan is a 50:50 hybrid of V. ashei and V. constablaei.

In the studies summarized here, we evaluated 1) the relative winter hardiness and deacclimation of V. ashei and V. constablaei, 2) the relative winter hardiness of V. ashei cultivars that could be used as parents, and 3) the relative winter hardiness of various combinations V. ashei and V. constablaei germplasm.

MATERIALS AND METHODS
In 2002, 'Tifblue' (V. ashei), 'Bluecrop' (V. corymbosum L.), 'Northcountry' (V. corymbosum × V. angustifolium Ait.), 'Little Giant' (V. constablaei × V. ashei), and a V. constablaei population were evaluated for deacclimation under field conditions over a period of 11 weeks from January 28 to April 7. In 2004, a group of 24 V. ashei cultivars were evaluated for mid-winter cold-hardiness on January 13 (Table 1). In 2004, we also evaluated mid-winter cold-hardiness in a variety of V. constablaei populations, V. constablaei - V. ashei populations, V. constablaei - V. ashei clones, and V. ashei cultivars on March 3 (Table 2).

Detached shoots of blueberry were assayed to determine either bud hardness or to evaluate rates of deacclimation under field conditions. Shoots were collected at the Philip E. Marucci Center for Blueberry and Cranberry Research and Extension at Rutgers University, Chatsworth, New Jersey. The LT50s of the buds (the temperature at which 50% of the buds are damaged) were measured by controlled freezing in a glycol bath (Forma Scientific, Marietta, Ohio) as previously described by Arora et al. (2000). For the freeze-thaw test, 3 shoots with at least 3 attached buds were frozen at each treatment temperature (-1°C to -28°C, at 2 °C increments), followed by visual evaluation after a 24h incubation at 23°C to determine percent damage. LT50 values were determined by interpolation from bracketing values.

RESULTS AND DISCUSSION
Figure 1 shows the LT50 values of 'Tifblue' (V. ashei), 'Bluecrop' (V. corymbosum), 'Northcountry' (V. corymbosum × V. angustifolium), 'Little Giant' (V. constablaei × V. ashei), and a V. constablaei population. Of note is that 'Little Giant' is more winter hardy and deacclimates more slowly than either 'Bluecrop' or 'Northcountry', and the pure V. constablaei population deacclimates extremely slowly. In a previous publication (Ehlenfeldt et al., 2003), we suggested that selections might best be compared as to how quickly they reached an LT50 of -15°C. Using this criterion, these materials reached an LT50 of -15°C at the following respective weeks: 'Tifblue' (Week 6), 'Bluecrop' and 'Northcountry' (Week 7), 'Little Giant' (Week 10), and the V. constablaei population (Week 11). The slow deacclimation of the V. constablaei population is also reflected in their late flowering date (50% flower on May 17, 2002 compared to April 28 for 'Bluecrop', data not shown).

This extreme hardiness and slow deacclimation led us to consider the possibility that northern-adapted rabbiteye types could be developed from V. ashei - V. constablaei hybrids. Just as (northern) highbush yielded “southern highbush” via V. darrowi Camp introgression, (southern) rabbiteye can yield “northern rabbiteye” via V. constablaei introgression. The particular value of this approach is that there is no inequality of ploidy levels or resultant sterility as there is in highbush × rabbiteye hybrids.

In the course of several years, such crosses were produced and selections were made. The most promising selections to date are: US 1055 - US 1057 (= US 874 x 'Premier') and US 1043 - 1045 (= US 866 × 'Beckyblue'). US 874 is a cross of NC 86-40-2 (V. constablaei) × NJ 89-158-8 (6x V. corymbosum). US 866 is a cross of NC 86-40-2 (V. constablaei) × NJ 89-158-8 (6x V. corymbosum). The 6x V. corymbosum was a product of the hybridization of two triploids (Ehlenfeldt and Vorsa, 1994), and represent unusual germplasm; however, we now have selections under development that use strictly V. ashei and V. constablaei.
The concept of “northern rabbiteye” holds great potential because *V. ashei* and *V. constablaei* are complementary for many characteristics. As noted previously, *V. ashei* is cold-sensitive, early flowering, late ripening, vigorous, and tends to “sucker”. Its fruit are seedy, (sometimes having grit cells), and it is relatively large-fruited. *V. constablaei* is cold-hardy, late flowering, mid-season ripening, only moderately vigorous, and primarily crown forming. Its fruit are small, and not objectionably seedy. In the hybrids many of these traits tend toward the more desirable characteristics, and it is particularly notable that most hybrids exhibit no objectionable grittiness in the fruit. The characteristics of “northern rabbiteye” so far, in the selections we have made can be summarized as: 1) excellent vigor, 2) high potential productivity, 3) late flowering (relative to rabbiteye), 4) winter hardiness (greater than most rabbiteye), 5) good / interesting fruit quality, often somewhat dark in color, 6) late ripening (compared to highbush, but earlier than rabbiteye), and 7) moderate fruit size.

Because we recognize the need for using the most cold hardy parents when trying to derive a cold-hardy hybrid, we evaluated the cold hardiness of a group of 24 rabbiteye cultivars in 2004 (Table 1). In this first year of screening, ‘Coastal’, ‘Powderblue’ and ‘Pearl River’ were found to be most cold hardy. ‘Pearl River’ is a *V. corymbosum × V. ashei* hybrid, and may derive some of its cold hardiness from its *V. corymbosum* parent.

Evaluations of LT$_{50}$ versus *V. constablaei* germplasm composition were also made in 2004 (Table 2). In this first year of screening, hybrids with between 50 and 100% *V. constablaei* germplasm were equally cold-hardy (noting that we could not measure below -28°C). Germplasm with 25% *V. constablaei* germplasm exhibited differing LT$_{50}$s depending upon parentage, but it should be noted that even at the date these evaluations were made, US 1056 and the ‘Climax’ × ‘Little Giant’ population were almost as winter hardy as the ‘Bluecrop’ measured in Figure 1. ‘Climax’ and ‘Delite’ (which are parents of the populations) had sustained natural cold damage so that an LT$_{50}$ could not be derived (i.e. they already had more than 50% damage). ‘Tifblue’ and ‘Baldwin’ were substituted since we already knew that these two cultivars possessed greater winter hardiness.

**CONCLUSION**

We are currently enacting several strategies in producing “northern rabbiteye”. These include: 1) utilization of the knowledge of cold-hardiness of rabbiteye (coupled with knowledge of traits such as suckering, fruit size, vigor, disease resistance, etc.), 2) introgression of *V. constablaei* into *V. ashei*, targeting useful combinations of 75 *V. ashei* :25 *V. constablaei* (50:50 combinations have insufficient size, color, and stature), 3) improvement of *V. constablaei* germplasm via introgression of *V. ashei* and subsequent back-crossing, and 4) recombination among hybrids with various germplasm combinations and percentages.

Recombination among hardy rabbiteye hybrids offers the potential of being able to select secondary hybrids adapted anywhere from the far southern U.S. to the far northern U.S. The greatest challenges in ultimately utilizing this germplasm are achieving earlier ripening and developing adequate fruit size. Although hybrid derivatives vary in cold hardiness, some compromises on bud hardiness may be acceptable if yield and vigor are sufficiently high.

**Literature Cited**


Tables

Table 1. LT₅₀ values of 24 V. ashei cultivars, January 13, 2004.

<table>
<thead>
<tr>
<th>LT₅₀ (°C)</th>
<th>Cultivar</th>
</tr>
</thead>
<tbody>
<tr>
<td>-13</td>
<td>Chaucer, Owen</td>
</tr>
<tr>
<td>-18 to -20</td>
<td>Beckyblue, Brightwell, Callaway, Delite, Garden Blue, Aliceblue, Bluebelle, Climax, Myers, Ethel</td>
</tr>
<tr>
<td>-21 to -23</td>
<td>Baldwin, Early May, Montgomery, Homebell, Southland, Woodard, Suwanee, Tifblue, Walker</td>
</tr>
<tr>
<td>-24 to -25</td>
<td>Coastal, Powderblue, Pearl River</td>
</tr>
</tbody>
</table>

Table 2. LT₅₀ versus V. constablaei germplasm composition on March 3, 2004.

<table>
<thead>
<tr>
<th>Germplasm or selection (%)</th>
<th>LT₅₀ (°C)</th>
<th>V. constablaei ancestry (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. constablaei populations (2)</td>
<td>-26 to -28</td>
<td>100</td>
</tr>
<tr>
<td>US 1080, US 1112</td>
<td>-25 to -28</td>
<td>75</td>
</tr>
<tr>
<td>ARS 99-89, Little Giant</td>
<td>-26 to -28</td>
<td>50</td>
</tr>
<tr>
<td>US 1043, Delite x Little Giant population</td>
<td>-23 to -25</td>
<td>25</td>
</tr>
<tr>
<td>US 1056, Climax x Little Giant population</td>
<td>-16 to -17</td>
<td>25</td>
</tr>
<tr>
<td>Baldwin, Tifblue</td>
<td>-19 to -21</td>
<td>0</td>
</tr>
<tr>
<td>Climax, Delite</td>
<td>damaged</td>
<td>0</td>
</tr>
</tbody>
</table>

Figures

Fig. 1. Field deacclimation of five different germplasm combinations in 2002. LT₅₀ represents the temperature at which 50% of the buds are damaged. Temperatures lower than -28° C could not be measured.